Acute and chronic open conversion after endovascular aortic aneurysm repair: A 14-year review

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Objective: **This study reviewed outcomes of patients requiring surgical conversion after endovascular abdominal aortic aneurysm (AAA) repair.**
Methods: **Records for all patients undergoing open conversion after endovascular AAA repair were reviewed.**
Results: **From 1993 to 2006, 574 patients underwent endovascular repair for AAA. Seventeen patients, including three patients who underwent prior endovascular repair at other centers, required surgical conversion with complete (n = 9) or partial graft removal (n = 8). Five patients required immediate conversion (acute), and 12 underwent delayed conversion 4 to 72 months after endovascular repair. Indications for acute conversion were large type I endoleak (n = 3, 60%), including one patient with graft migration, and retroperitoneal bleeding (n = 2, 40%). Indications for chronic conversion were endoleak with increasing aneurysm size (n = 9, 75%), stent fracture without endoleak (n = 1, 8%), delayed retroperitoneal bleeding (n = 1, 8%), and infection (n = 1, 8%). Suprarenal aortic cross-clamping was required in two patients (12%), and endograft components were retained in eight (47%). An aortic occlusion balloon placed through the body of the existing endograft facilitated proximal control in three patients. There were two perioperative deaths in the acute conversion group (2/5; 40%) and none in the delayed conversion group ($P = .04$). Five-year actuarial survival was 71.9%. Mean follow-up was 41.6 ± 32.2 months. Retained endovascular components in patients with partial graft removal remained stable during follow-up.**
Conclusions: **Surgical conversion after endovascular AAA repair can be performed without suprarenal clamping in most patients. Endovascular aortic control with a balloon avoids suprarenal exposure. Partial endograft removal in selected patients facilitates open conversion and appears durable. Acute conversion is associated with increased mortality. (J Vasc Surg 2007;46:642-7.)**

The need for secondary interventions after endovascular aneurysm repair is still relatively frequent despite the development of newer-generation stent grafts. The reintervention rate at 1 year has been reported at 8% to 42% among different series.[1-5] Most complications can be managed percutaneously[6]; however, open conversion may still be required. This is a potential source of increased morbidity in patients undergoing endovascular repair of abdominal aortic aneurysms (AAA). Previous reports have advocated the use of a midline approach with supraceliac clamping and extension of the aortotomy proximal to the renal arteries, with associated perioperative mortality as high as 20%.[7,8]

We report our experience with 17 patients requiring acute or chronic open conversion after prior stent graft placement. We also describe the technical modification to avoid suprarenal exposure by an aortic occlusion balloon through the body of the endograft and inflated in the suprarenal visceral aorta for graft removal.

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MATERIALS AND METHODS

All patients who underwent open conversion after endograft placement for infrarenal aortic aneurysm between July 1993 and August 2006 at the University of California, Los Angeles were included in this retrospective review. Conversions were considered acute if performed immediately at the time of endovascular graft deployment. Conversions were considered chronic if performed during a separate hospitalization after initial endograft placement. The study excluded patients who did not have graft deployment at time of the initial operation who required open repair.

The medical records were retrospectively reviewed, and the preoperative risk factors were examined, including age, gender, aneurysm size, presence of documented coronary artery disease, congestive heart failure, prior myocardial infarction, pre-existing arrhythmia, hypertension, chronic obstructive pulmonary disease, pulmonary hypertension, smoking history, claudication, and hyperlipidemia. Presenting symptoms and indications for conversion were also noted. The intraoperative variables examined included type of skin incision, total estimated blood loss, need for suprarenal aortic clamping, use of an aortic balloon for hemostasis, placement of tube vs bifurcated graft, and partial vs complete device removal. Types of preoperative imaging were also specified.

The postoperative course was obtained from the medical record with documentation of major perioperative (<30 days) complications, including myocardial infarction,

arrhythmia, respiratory failure, pleural effusion, renal failure, bleeding, and death. Elevated serial troponin levels documented myocardial infarction. Respiratory failure was defined as the need for reintubation after the initial postoperative extubation. Renal failure was considered a serum creatinine level >2.0 mg/dL or a rise in creatinine >1.0 mg/dL above baseline. Bleeding was defined as postoperative blood loss requiring reoperation. Perioperative death was defined as occurring before discharge or ≤30 days of surgery. Time to extubation, length of intensive care unit stay, days to feeding, and hospital length of stay were also noted.

Statistical analysis was performed where applicable using Excel 2003 (Microsoft, Redmond, Wash). For most categories, a two-tailed Student *t* test was used. Statistical significance was assigned to values at the $P = .05$ level.

This study was conducted with the approval of the University of California Institutional Review Board.

RESULTS

During a 14-year period, 17 open conversions (16 men, 1 woman) were performed at our institution with either partial or complete endograft removal (Table). Three (18%) patients had their initial endovascular repair performed at outside hospitals, and the remainder had their initial operation performed at our institution. Twelve (71%) patients underwent chronic conversions, and 5 (29%) patients underwent acute conversion after device placement.

The mean patient age was 77.6 ± 6.2 years. Twelve patients (71%) had pre-existing coronary artery disease, 15 (88%) were medically treated for hypertension, 4 (24%) sustained prior myocardial infarction, 7 (41%) had preexisting cardiac arrhythmia, 2 (12%) had type II diabetes, 15 (88%) had a prior smoking history, 4 (24%) had chronic obstructive pulmonary disease, and 1 (6%) had moderate pulmonary hypertension. One patient (6%) had preoperative renal insufficiency (creatinine >2.0 mg/dL). No significant differences were noted in age or preoperative risk factors between the acute and chronic conversions groups.

The mean aneurysm size at conversion was 7.0 ± 1.4 cm. The mean sizes in the acute and chronic groups were 6.5 ± 0.9 and 7.1 ± 1.6 cm, respectively ($P = .45$). Mean time to conversion in the chronic group was 26.4 ± 25.0 months. Preoperative computed tomography (CT) scans were obtained in 17 (100%) patients, and 13 (76%) had preoperative aortic angiography. Indications for the five acute conversions were intraoperative aortic rupture (n = 2, 40%) and type I endoleak (n = 3, 60%), including one with complete graft migration into the aneurysm sac after deployment, noted intraoperatively. All acute conversions were performed at the time of attempted endovascular repair. Except for the two patients with acute aneurysm rupture, all other patients in the acute conversion group were hemodynamically stable.

Indications for chronic conversions were type I endoleak in three (25%), type II endoleak in five (42%), and one patient (8%) each with type III endoleak, type IV endoleak, stent fracture without endoleak, delayed retroperitoneal bleeding, and infection. One patient (8%) with an enlarging aneurysm sac after initial endovascular repair had no evidence of endoleak intraoperatively or angiographically and the increasing size was attributed to endotension. One patient was found to have type II and type III endoleak during operative exploration, and one had type II and type IV endoleaks. The type IV endoleak was not visualized on preoperative imaging but consisted of brisk bleeding through the interstices of the graft material at an attachment site to the metallic framework. All patients converted for endoleak, regardless of type, were noted to have increasing size of the aneurysm sac on serial CT scans.

Specific stent grafts removed included Ancure (Guidant, Menlo Park, Calif) in 13 patients (76%), and Zenith (Cook, Bloomington, Ind), Excluder (Gore, Flagstaff, Ariz) and Aneurx (Medtronic, Minneapolis, Minn) devices in one patient each. The remaining patient who presented for late conversion underwent prior stent graft placement in China and the specific device used was unclear.

The mean time to open conversion (from date of original operation) was 26.5 ± 25.0 months. The mean estimated intraoperative blood loss was 882.0 ± 565.0 mL. No statistically significant difference was noted between groups. Total mean operative time for both groups was 368.3 ± 91.2 minutes. A statistically significant increase was noted in the overall operative time in the acute group compared with the chronic group (447.0 ± 75.3 minutes vs 337.2 ± 74.0 minutes; $P = .02$).

A retroperitoneal approach was used in nine (53%) patients, all of which were chronic, elective conversions. No retroperitoneal incisions were performed in the acute conversion group. Transperitoneal midline laparotomy was used in seven patients (41%): five in the acute conversion group (29%) and two (12%) in the chronic conversion group. One patient (6%) underwent a bilateral subcostal incision for exposure.

Suprarenal aortic crossclamping was required in one patient (6%) and, in three patients (18%) in the chronic conversion group, aortic control was achieved by inflating an intraluminal aortic occlusion balloon proximal to the endograft before opening the aneurysm. The stent graft was completely removed in nine patients (53%). In eight patients (47%), one or both of the iliac limbs were retained and used to sew a distal graft-to-graft anastomosis. No kinking of distal endograft limbs was noted. No patients required hypogastric ligation with extension of the distal anastomosis to the external iliac arteries.

In one patient (5%) with a type II endoleak and enlarging aneurysm, the proximal portion of the graft was retained and used for the new proximal graft–to–graft/aorta anastomosis. This patient had a proximal Excluder endograft that was well incorporated, without evidence of endoleak, and transection 5 cm distal to the attachment zone allowed for infrarenal clamping. A bifurcated graft was used in 10 patients (59%) for aortic reconstruction and a tube graft was used in 6 (35%). In the patient who underwent explant for chronic graft infection, an axillobifemoral bypass was performed before abdominal exploration and complete graft removal.

Table. Individual details of patients who underwent endograft conversion

Patient	*Conversion date*	*Acute or chronic*	*Time to conversion*	*Indication*
A	7/18/93	Chronic	4 days	Delayed retroperitoneal bleeding
B	10/1/93	Acute	Immediate	Type I leak
C	4/18/95	Chronic	17 months	Stent fracture with migration
D	10/22/96	Chronic	37 months	Type I endoleak; increased aneurysm size; stent fracture
E	2/19/97	Acute	Immediate	Aortic rupture
F	2/25/97	Acute	Immediate	Aortic rupture
G	8/22/97	Acute	Immediate	Type I endoleak; increased aneurysm size
H	12/2/97	Acute	Immediate	Severe graft migration
I	11/27/01	Chronic	15 months	Type I endoleak; increased aneurysm size
J	10/23/02	Chronic	56 months	Type II endoleak; increased aneurysm size
K	11/5/02	Chronic	13 months	Infected endograft
L	11/6/02	Chronic	56 months	Type II endoleak; increased aneurysm size
M	8/20/03	Chronic	32 months	Type II and type III endoleaks; increased aneurysm size
N	4/27/04	Chronic	41 months	Type II endoleak; increasing aneurysm size
O	12/5/05	Chronic	72 months	Large type I endoleak; increasing aneurysm size
P	8/7/06	Chronic	14 months	Type II and type IV endoleak; increasing aneurysm size
Q	10/6/06	Chronic	22 months	Type II endoleak; increasing aneurysm size

MI, Myocardial infarction; *IMA, Inferior mesenteric artery*; *POD*, postoperative day.

The 5-year actuarial survival was 71.9%. Two patients (12%) who underwent acute conversion died perioperatively of a myocardial infarction on postoperative day 5 and acute respiratory failure secondary to an aspiration on postoperative day 4. There were no intraoperative deaths and no perioperative deaths in patients who underwent late chronic conversion.

The mean number of days for mechanical ventilation was 1.0 ± 1.2 days in the acute conversion group and 0.58 ± 0.8 days in the chronic conversion group ($P = .4$). Mean days to feeding were 7.0 ± 0.0 days in the acute group and 3.7 ± 1.3 days in the chronic group ($P = .001$). Patients who underwent retroperitoneal repair had a statistically significant shorter time to feeding than patients who underwent transperitoneal repair (3.5 ± 1.2 vs 5.7 ± 1.8 days, $P = .02$) Of note, one patient in the chronic conversion group demonstrated a prolonged postoperative ileus and was found to have a malignant ampullary tumor. The patient later underwent a Whipple resection in the perioperative period. Because our goal was to compare the effects of conversion on postoperative ileus, the patient was excluded from this comparison.

No patients required reoperation ≤30 days. One patient (6%) presented with a pleural effusion and required chest tube placement, with subsequent resolution.

The mean hospital length of stay was 9.6 ± 6.4 days, with no significant difference between the two groups. There was no significant difference in length of stay between patients who underwent retroperitoneal vs transperitoneal repair.

The mean follow-up period was 41.6 ± 32.2 months. Eight patients (47%) have been followed up with a postoperative CT scan demonstrating no evidence of aneurysm leak or expansion after open repair. As mentioned, one (6%) perioperative myocardial infarction resulted in respiratory failure and death, and one patient (6%) experienced respiratory failure and reintubation after and aspiration event. Both patients had undergone prior acute open conversion. In the chronic conversion group, acute postoperative renal failure requiring long-term hemodialysis developed in one patient, and one patient was readmitted 17 days later for chylous ascites that resolved after percutaneous drainage and bowel rest. No perioperative myocardial infarctions or episodes of respiratory failure occurred in the chronic conversion patients.

DISCUSSION

Few reported series have focused on the clinical consequences of open conversion and graft removal after endovascular AAA repair.[5,9-11] This operation has traditionally

Table. Continued

Device	*Retained components*	*Approach*	*Prior failed endovascular intervention*	*Outcome*
Ancure	None	Transperitoneal	None	Unrelated death at 67 months
Ancure	None	Transperitoneal	None	Alive at 72 months; lost to follow up
Ancure	None	Transperitoneal	None	Alive at 101 months
Ancure	None	Transperitoneal	None	Unrelated death at 52 months
Ancure	None	Transperitoneal	None	Respiratory failure; in-patient death
Ancure	None	Transperitoneal	None	Alive at 85 months
Ancure	None	Transperitoneal	None	Alive at 67 months
Ancure	None	Transperitoneal	None	MI on POD 5; in-patient death
Ancure	One iliac limb	Retroperitoneal	Proximal placement of Palmaz stent	Alive at 41 months
Ancure	Two iliac limbs	Retroperitoneal	Embolization of patent iliolumbar and lumbar arteries	Alive at 6 months; lost to follow up
AneuRx	None	Retroperitoneal	None	Alive at 43 months
Ancure	Two iliac limbs	Retroperitoneal	Coil embolization of IMA	Alive at 41 months
Ancure	Two iliac limbs	Retroperitoneal	Proximal placement of Palmaz stent, coil embolization of IMA and lumbar arteries	Death at 3 months; renal failure complications
Ancure	Two iliac limbs	Retroperitoneal	Embolization of patent iliolumbar and pudendal artery branches	Alive at 28 months
Unknown (placed in China)	Two iliac limbs	Retroperitoneal	None	Alive at 15 months
Zenith	Two iliac limbs	Retroperitoneal	Embolization of patent lumbar arteries and IMA	Alive at 2 months; lost to follow-up
Excluder	Two iliac limbs, proximal endograft	Retroperitoneal	Embolization of patent iliolumbar arteries; relining with new endograft	Alive at 6 months

been associated with poor outcomes and high mortality. An early review by May et al,[9] reported a 17% incidence of renal failure requiring hemodialysis and a 17% procedure-related mortality after open conversion. Lyden et al[10] reported a 4.5% incidence of open conversion during a 4-year period. All patients underwent elective, late open conversions. Supraceliac aortic cross-clamping was performed in all patients in their series. The mean operative blood loss was 4700 mL, and the mean hospital length of stay was 19.8 days. Extension of the aortotomy proximal to the renal ostia was required in two patients to facilitate removal of the proximal portion of the graft, and the perioperative mortality was 20%. In a review of 11 patients, Lipsitz et al,[11] reported 100% mortality (2/2) in patients who required supraceliac aortic clamping during open late conversion.

In a recent series by Verzini et al,[5] nine early conversions and 29 late conversions were reported. The mortality in the acute conversion group was 22%. No late actuarial survival was reported. Most of the acute conversions were attributed to vessel wall calcification and failed cannulation. These patients were not included in our series. Of the 29 late conversions that were performed, only 17% underwent attempted secondary endovascular interventions before open conversion. In our series, chronic conversion group, most patients were converted only after failed secondary endovascular interventions.

The effects of prolonged suprarenal aortic clamp times during open aortic aneurysm repair and increased perioperative mortality have been documented.[12] Avoidance of suprarenal clamping in our series likely contributes to the absence of perioperative morbidity and mortality in the chronic conversion group. Published series have advocated suprarenal clamping during conversion because of proximal fixators associated with various stent graft models and their proximity to the infrarenal neck of the aneurysm (ie, Vanguard, Boston Scientific, Natick, Mass; Talent, Medtronic AVE, Santa Rosa, Calif; Ancure, Guidant, Menlo Park, Calif.).[10] The difficulty in removing these proximal attachment systems can contribute to prolonged suprarenal clamp times, prolonged renal ischemia, and damage to the adjacent aortic wall, further complicating repair. In our series, 13 (76%) of 17 patients underwent explant of previously placed Ancure grafts, a first-generation stent graft that contained angled proximal metal attachments hooks and a self-expanding cylindrical metal frame.

Certain technical modifications in selected patients have contributed to the improved results in our chronic conversion group. Once dissection of the proximal aneurysm neck is achieved, we use a 33-mm aortic occlusion balloon (Boston Scientific) placed in a 14F sheath (Cook), through the anterior wall of the stent graft, and position the device at the level of the suprarenal aorta (Fig 1, *A* and *B*)

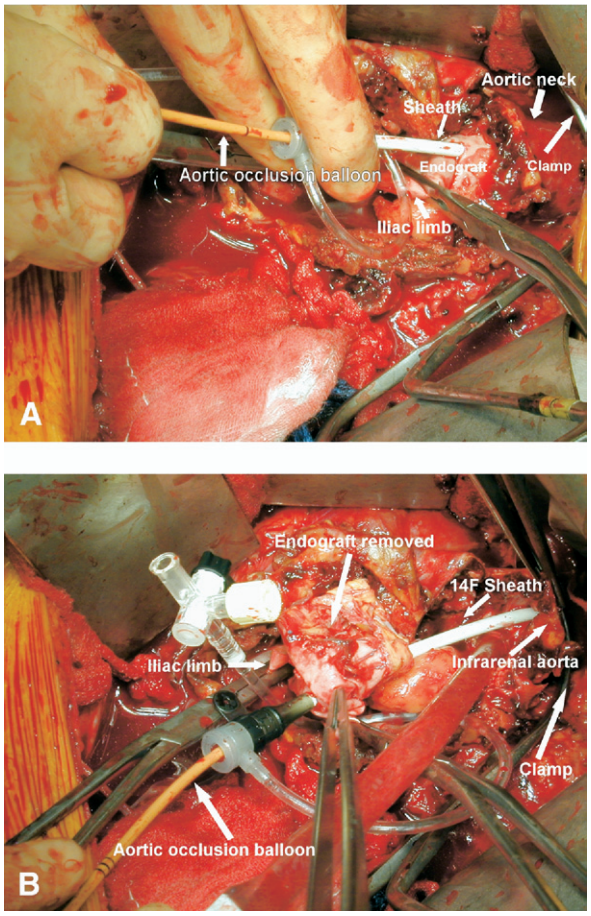

Fig 1. A and **B,** Insertion of an arterial sheath through the body of the existing endograft and inflation of an aortic occlusion balloon in proximal aorta for removal of prosthesis.

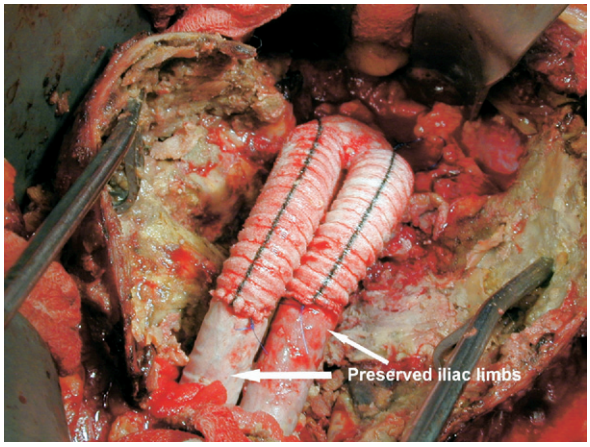

Fig 2. Preservation of iliac limbs from the existing endograft facilitates open conversion.

The balloon inflation allows proximal vascular control and the ability to open the aneurysm sac completely for full exposure of the stent graft without the need for operative exposure of the visceral aorta. This technique also allows removal of any proximal metal barbs or hooks without interference from an adjacent or superimposed aortic cross-clamp at this time.

Once the graft is removed, a cross-clamp can be placed across the infrarenal aneurysm neck and clamped after balloon removal. We advocate the use of this technique instead of suprarenal aortic cross-clamping whenever possible. If the patient has a large type I endoleak, temporary partial clamping of the neck, opening the aneurysm, and then inserting the balloon would be the recommended sequence. Alternatively, placement of an aortic occlusion balloon through a femoral approach can be used in cases where opening the aneurysm sac before aortic control is not an option.

The presence of infection clearly mandates complete removal of the stent graft and all components and reconstruction with an extra-anatomic bypass or cryopreserved allograft. In the absence of infection, we prefer to selectively remove nonfunctional graft components and keep the proximal portion of the endograft body or distal limbs in place when these components appear sealed, free of kinking, and well incorporated. After difficult graft removal, the arterial wall may become thin and denuded, making an anastomosis more complicated and increasing the chances of anastomotic bleeding; thus, preservation of well-incorporated components is preferable, allowing a graft-to-graft anastomosis (Fig 2). This is particularly important when suprarenal fixation is present. If it is not necessary to remove the proximal portion of these devices, graft transection and inclusion of both the arterial wall and the endograft components in the anastomosis is best. Follow-up has demonstrated the durability of this selective approach.

The two perioperative deaths (40%) in the acute group in this series highlight the significant morbidity associated with immediate open conversion, despite the avoidance of suprarenal clamping, and compare favorably with published reports.[7,11] The disadvantages of immediate open conversion include difficult positioning for a retroperitoneal approach, especially if the patient is hemodynamically unstable. In our series, immediate conversion was associated with longer operative times and an increased risk of perioperative death compared with the delayed conversion group. Both were statistically significant. The benefits of retroperitoneal exposure in terms of shortening overall length of hospital stay and decreasing postoperative respiratory failure have been described.[13,14] In this series, patients who underwent transperitoneal exposure demonstrated increased postoperative ileus compared with retroperitoneal exposure. No difference was noted in hospital length of stay between these two groups.

Patients who undergo acute open conversion after endograft deployment and malpositioning or with a major endoleak have received nephrotoxic contrast agents that may contribute to perioperative renal dysfunction, espe-

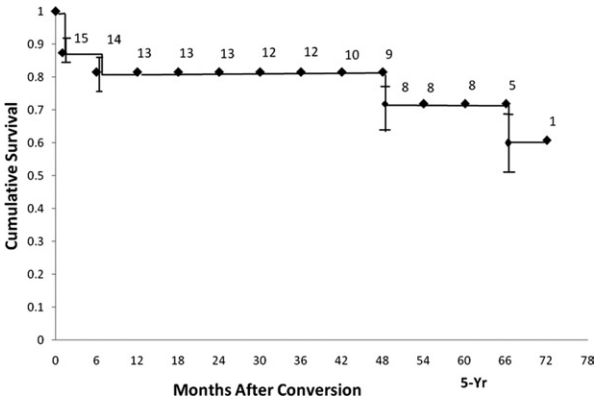

Fig 3. Cumulative survival after endograft conversion.

cially if prolonged suprarenal clamping becomes necessary. Progression to immediate open repair in otherwise stable patients should thus be aborted, if possible, and planned for delayed elective repair.

The need for late conversion based on our experience was about 2% at 5 years (Fig 3). Considering that most of the explanted devices were Ancure, a device system that lacked ancillary components to correct some of the issues that led to conversion, suggests that the need for open repair after endovascular aneurysm repair will likely be lower in the future.

CONCLUSION

Surgical conversion after endovascular AAA repair can be achieved without suprarenal clamping in most patients. Endovascular control with a balloon reduces the need for suprarenal exposure and should be used instead of suprarenal aortic cross-clamping whenever possible. Partial endograft removal in selected patients facilitates open conversion and appears durable. Retroperitoneal exposure is associated with decreased postoperative ileus after endograft conversion. Acute conversion appears to increase perioperative mortality. Long-term results with improving technology will likely reduce the need for open conversion after endovascular repair of aortic aneurysms.

AUTHOR CONTRIBUTIONS

Conception and design: JJ, WQ
Analysis and interpretation: JJ, WQ, WM
Data collection: JJ
Writing the article: JJ, WM, WQ
Critical revision of the article: WQ
Final approval of the article: WQ
Statistical analysis: JJ, WQ
Obtained funding: JJ, WQ
Overall responsibility: WQ

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